TAVEL, F. VON.—*Vergleichende Morphologie der Pilze.* Jena, 1892, 8vo, pp. 11, 208, figs. 90.

This book puts the whole Brefeldian system into such a compact and lucid form that he who runs may read. The revolutionary work done by Dr. Brefeld and his assistants during the last twenty years in every group of fungi and embodied in ten large "Heften," with more to follow, is here condensed into less than 225 pages, and yet completeness and perspicuity of expression, so far as regards essential features, are everywhere apparent. That Dr. von Tavel is well fitted for this task goes without saying, since he was Dr. Brefeld's assistant for a number of years, and is joint author with him of Heften IX and X on Hemiasci and Ascomycetes.

According to the views here set forth, fungi consist of two primary groups: (1) The Phycomycetes, or algal fungi, consisting of a single cell and having sexual functions; and (2) the Mesomycetes and Mycomycetes, or higher fungi, consisting of a many-celled thallus and entirely destitute of sexual organs. The Phycomycetes have a thallus resembling that of the Siphoneæ and were undoubtedly derived from the algæ. They subdivide naturally into two quite distinct groups, the Oomycetes and Zygomycetes. The Oomycetes resemble the Oophyceæ both in the thallus and in the reproductive system. In each group the organism consists of a nonseptate, sparingly branched cell, which reproduces sexually by antheridia and oogonia, and nonsexually by swarm spores developed in sporangia. But the Oomycetes show degenerations and retrogressions which appear to be adaptations to a more terrestrial life. Especially noteworthy is the progressive loss of sexuality.

The group is divided into six families, including Entomophthoreæ, which stands midway between Oomycetes and Zygomycetes, having reduced antheridia and oogonia which conjugate, and an abundant conidial fructification. Beginnings of conidial fructification also appear in some of the other families. In Zygomycetes the thallus is one-celled and agrees completely with that of the Oomycetes, but the fructification is different. In this group there is still further degeneracy in the sexual reproduction. Instead of the union of specialized sporangia (antheridia and oogonia) to produce the zygospore, there is simply a conjugation of the slightly differentiated beginnings of such sporangia, i. e., the conjugating threads are only slightly swollen and the male and female organs can not be distinguished. Nonsexual sporangia are present as in Oomycetes, but the spores have lost their cilia with the more decided adaptation of these plants to a dry-land life. In the possession of a one-celled thallus the Zygomycetes are also like the algæ, and they resemble the Conjugatæ in conjugation, but not otherwise. The first five families are exosporangic, producing sporophores anywhere on the mycelium; the other two, Rhizopiæ and Mortierellaceæ, have progressed a step further and are carpo-sporangic, bearing their sporophores on specially

differentiated, stolon-like threads, which arise from the ordinary mycelium.

The higher fungi, i. e., the most highly developed, consist of the Ascomycetes and Basidiomycetes, or so-called Mycomycetes, and the intermediate Hemiasci and Hemibasidia, the so-called Mesomycetes, connecting the higher fungi with the Phycomycetes. The sexual organs, which are destitute of function in some of the Oomycetes and still further degraded in Zygomycetes, disappear altogether in the higher fungi and are not found even in a rudimentary state, whereas nonsexual methods of reproduction take on a compensating multiplicity of forms. Originally the nonsexual form was a sporangium, as in *Mucor mucedo*, and its change into a spore (conidium) can be followed step by step through the Thamnidiæ and Chætocladiaceæ. In the Choanephoreæ the conidia are still accompanied by the sporangia, but in the Chætocladiaceæ the latter have disappeared, and it is precisely from this group of Zygomycetes that the Basidiomycetes appear to have arisen. From this point of view there are three types of Zygomycetes: (1) Forms with sporangia only, (2) forms with sporangia and conidia, (3) forms with conidia only. Among the sporangial forms, moreover, *Mortierella rostafinskii* shows a distinct advance into a sporangial fruit, the beginning of which may be seen even in Rhizopeæ. Finally, in *Chlamydomucor racemosus* there has developed an additional, purely accessory spore, the chlamydospore, which occurs either as a chlamydospore proper or simply as an oidium. As already stated, all of these nonsexual spore forms, sporangial, conidial, and chlamydosporous, occur in great variety in the higher fungi. In the Hemiasci and Ascomycetes we have forms which fructify in sporangia only, or by sporangia and conidia, and these may be designated the *sporangial series* of the higher fungi. On the contrary, in the Hemibasidia and the Basidiomycetes there are no sporangia, but only conidia. These fungi evidently had their origin in the Zygomycetous Chætocladiaceæ and may be designated the *conidial series* of the higher fungi. Chlamydospores occur in both, and both sporangia and conidia are modified and specialized. The sporangium in Zygomycetes varies as to form, size, and number of its spores in the same species, but in the higher fungi definiteness becomes more and more pronounced until in Ascomycetes the sporangium becomes an ascus having a determinate shape and bearing a definite number of spores. In these particulars the Hemiasci form a transition group, their sporangial fructification being ascus-like, but more variable than in Ascomycetes. In the conidial series it is the conidiophore which has become specially developed. In Zygomycetes also the conidiophore varies in form, size, and number of its spores. In the Basidiomycetes it has been specialized into a basidum of definite form and bearing a definite number of spores. Here, again, there is an intermediate group, the Hemibasidia, connecting the basidia-bearing forms with the much simpler Zygomycetes. The accessory spore form, i. e., the chlamydo-

spore, remains indefinite in both series. According to this view, all of the higher fungi had their origin in Zygomycetes, and the two series simply developed in different directions, one series excluding sporangia and developing specialized conidiophores (basidia), while the other series retained indefinite conidiophores, but developed sporangia of a very precise character (asci).

The Hemiasci consist of three families, (1) Ascoideæ, (2) Protomycetes, and (3) Theleboleæ. In these simple forms the sporangium becomes ascus-like, but is still indeterminate as to form, size, and number of its spores. The spores are usually shot out with considerable force, showing in this particular a greater adaptation to terrestrial life than is found in most Zygomycetes. The Ascoidæ have free sporangia, as in Mucor, and conidia. The Protomycetes also have free sporangia and conidia, but the former are preceded by chlamydospores. The Theleboleæ have sporangial fruits, the condition seen in *Mortierella rostafinskii* having been carried a step farther by the reduction of the sporangiophore to a mere rudiment and the extension of the basal weft of mycelium into an envelope.

The Ascomycetes are characterized by the presence of the ascus, which is simply a sporangium that has become determinate in form, size, and number of its spores. In very many cases this form of fructification is accompanied by conidia and chlamydospores. When ripe the spores of most Ascomycetes are shot out of the ascus with great energy. Sexual organs do not occur in any of the forms, and the earlier observations ascribing sexuality to various Ascomycetous fungi are misinterpretations. The Ascomycetes are divided into Exosporangial and Carposporangial forms. The Exoasci are the simpler, having naked asci, borne directly on the mycelium. They include two families, Endomycetaceæ and Taphrineæ. The Carpoasci, which form the bulk of the Ascomycetes, have fruit bodies. The asci are not naked and do not arise directly from the mycelium, but in special organs, which are composed of fertile or asci-bearing hyphæ, and of sterile threads, which form the walls of the envelope. In most cases asci are not borne singly, but in great numbers in a hymenial layer. The simplest ascus fruits are angiocarpous. In the more highly differentiated Pyrenomycetes they have a special ostiolum. In another series of forms, i. e., Hysteriaceæ and Discomycetes, the fruit body may be called gymnocarpous, being closed at first but afterward open. Of much importance in the Carpoasci are the accessory fruit forms. In addition to ordinary free conidia and chlamydospores, there are conidia which have reached a higher grade of development, being produced within special fruit bodies resembling ascus fruits (the pycnidia). Still another fruit form is possible in this group, but has not been found, viz, ordinary sporangia. The simplest form of conidia appears in the Taphrineæ, being developed directly from the ascospore, even before its escape from the ascus, or else from another conidium. The next advance is the production of a germ tube on which

the conidia are borne. From this it is but a short step to mycelium, bearing conidia anywhere on its surface, a common occurrence in the Carpoasci. From simple forms like these the conidial development can be traced through coremia and more complex stroma-beds into its highest specialization, the closed fruit bodies known as pycnidia. Pycnidia are symphogenetic or meristogenetic according as they are pseudoparenchymatous, i. e., developed from a hyphæ complex, or produced by ordinary cell division, a common method in many cases. Between these two extremes are numerous intermediates. Free conidiophores, as well as conidial fruits, bear, as a rule, only one sort of spores, but sometimes, as in Diaporthe, the last produced may be of a different shape from the first. Succedaneous spore formation is regarded as a lower type than simultaneous, because the latter is more restricted. Chlamydospores appear in the Carpoasci in two forms, viz, as true chlamydospores and as oidia, but neither one is very common. Although the ascus is the highest type of fructification in this group, it is relatively the rarest. Often the fungus reproduces itself for many generations without developing asci, and for this reason many conidia and chlamydospores have been classed among the *fungi imperfecti*, the free conidiophores, as Hyphomycetes; the conidia beds as Gymnomycetes; and the pycnidia as Sphæropsidiæ, Cytisporaceæ, and Phyllostictaceæ. In many cases an exact determination of their place in the natural classification is possible only when identical forms are obtained from ascospores by artificial cultures, but the constant occurrence of two forms together renders their genetic connection probable. A great number of the Carpoasci live parasitically on algæ, forming lichens. The most of these are Pyrenomycetes and Discomycetes. In some lichens the alga forms the greater part of the thallus; in others, the fungus. Ascending from simple to complex forms, the Carpoasci are classified into (1) Gymnoasci, (2) Perisporiaceæ, (3) Pyrenomycetes, (4) Hysteriaceæ, (5) Discomycetes, and (6) Helvellaceæ. Sixty-five pages are devoted to the Hemiasci and Ascomycetes, each one pregnant with new views or interesting observations; but some of the most important statements are to be found in the last part of the book, dealing with the second or conidial series of the higher fungi. Here divergence from earlier views of classification is the most pronounced.

This series fruits exclusively by conidia. Beginning with certain Zygomycetes, the evolution of the conidial fructification can be traced step by step through the Hemibasidia into the Basidiomycetes, where it reaches the highest stage of development by the conversion of the indefinite conidiophore into the definite basidium. Chlamydospores occur in the Hemibasidia as well as in the Hemiasci, but while in the Protomycetaceæ the chlamydospores always grow out into a sporangium; in the Hemibasidia they grow out exclusively into conidiophores. All Hemibasidia have two kinds of spores, conidia and chlamydospores. The latter are constant and are the most striking spore forms, which is

also true in Protomycetes. The chlamydospores produce a sporophore, as in Chlamydomucor, but while it is accidental there, it is constant here, and while there it is a sporangiophore, here it is a basidium-like conidiophore. This intermediate group connecting Zygomycetes with Basidiomycetes separates naturally into two sub-groups, Ustilagineæ, with septate conidiophores (promycelia) bearing conidia chiefly on their sides; and Tilletiæ, with undivided conidiophores (promycelia) bearing the conidia in a whorl at the apex.

The Basidiomycetes are a very large group, rich in forms. Their most important character is the possession of basidia. The basidium is a conidiophore, which has become definitely restricted in shape, size, and the number of its spores. While an ordinary conidiophore produces spores one after another, indefinitely, from any suitable part, the basidium produces only a definite number of spores, only once, and in a particular place, and after their separation it shrivels. There is also less variation in the size and shape of the individual spores. Only in rare cases do the basidiospores become several-celled before their separation from the basidium, and this, as in similar cases elsewhere, is to be looked upon simply as an anticipation of germination phenomenon. Most basidia bear 4 spores; rarely they bear 2, 6, or 8 spores. These variations may all occur in the members of a single genus, e. g., Hypochnus. As a rule the basidiospores are borne on comparatively long sterigmata. Like the Hemibasidia, the Basidiomycetes are separable into two corresponding, but more highly developed groups. In order that the basidium-like conidiophore of the Ustilagineæ shall become a true basidium, its septa must be limited to a definite number, the position and number of sterigmata must also become definite, and finally only a single spore must be abjuncted from each sterigma. This is exactly what occurs in the Protobasidiomycetes, the first of the two subdivisions. The second and higher group consists of the true or Autobasidiomycetes, corresponding to the Tilletiæ; i. e., they have nonseptate basidia, but bear a definite number of basidiospores. In contrast to the Ascomycetes, naturally separable into Exoasci and Carpoasci, the formation of the fruit body in the conidial series is of secondary importance. Both Proto and Auto basidiomycetes begin with acarpous fruits, and from these have been developed the more highly organized forms having fruit bodies. The Protobasidiomycetes, or fungi having a septate basidium, are separable into four distinct groups: (1) Uredineæ, having horizontally septate basidia, always free, never borne in fruit bodies, and always produced from a chlamydospore (teleutospore); (2) Auriculariæ, with basidia resembling Uredineæ, but gymnocarpous, i. e., having fruit bodies which from the beginning form open hymenia; (3) Pilacreæ, which also have horizontally septate basidia, but angiocarpous or closed fruit bodies; (4) Tremellineæ, having vertically divided basidia borne in gymnocarpous fruits. The Uredineæ are especially rich in chlamydospore forms; teleutospores, uredospores, and æcidiospores are all types of this form.

The Autobasidiomycetes have undivided basidia, which bear spores only on their apex. The Hymenomycetes make up the bulk of this group and appear to have been derived from Tilletia-like forms, while the Dacryomycetaceæ have genetic relationships with the Tremellineæ, and the Gasteromycetes with the Pilacreæ, to which they are closely connected by Tylostoma. The basidia, however, in this great group are so similar that some other means of classification must be resorted to, and this is found in the fruit body. Proceeding from lower to higher, the group is divisible into (1) Dacryomycetes, with basidia split downward into two forks, but not septate; (2) Hymenomycetes, with short cylindric or club-shaped simple basidia, bearing usually 4 spores on delicate sterigmata, and having a variable but always finally gymnocarpous or only semi-angiocarpous fruit body; (3) Gasteromycetes, with basidia borne inside of various sorts of angiocarpous fruit bodies; (4) Phalloideæ, having the basidia borne during the early stages in a closed fruit body and subsequently pushed up through this and exposed to the air on a rapidly elongating sporophore.

The Dacryomycetes have also ordinary conidia and oidia. The simplest Hymenomycetes, the Tomentelleæ, are destitute of a fruit body, and the more complex forms appear to have originated from these. Next come the gymnocarpous Thelephoreæ and Clavariæ; then the hemiangiocarpous forms, bearing the hymenium on the under surface of the pileus, on spines in Hydnei, on the walls of pores in Polyporei, and on lamellæ in Agaricineæ. The Polyporei are mostly poor in accessory fruit forms, but oidia occur in some species of Polyporus, Dædalea, and Lenzites, while Heterobasidion (*Polyporus annosus*) bears ordinary conidia, and Oligoporus and Fistulina bear chlamydospores, the former very abundantly. The genus Oligoporus was formerly described under Polyporus, and its chlamydospores were supposed to be something entirely different and were put into the form-genus Ptychogaster. In this genus Oligoporus, the formation of chlamydospores occurs in essentially the same manner as in *Chlamydomucor racemosus* or in a Ustilago. Various Agaricineæ produce sclerotia and rhizomorphs, but no ordinary conidia have been found. It must be remembered, however, that a great many forms have not been studied critically. Oidia, on the contrary, occur in many genera and are specially abundant in the genus Nyctalis. Chlamydospores are also abundant in this genus, and may occur even in the hymenial layer, but have not been discovered in other genera.

In Gasteromycetes the fruit body is not only angiocarpous in early stages, like that of many Hymenomycetes, but remains so. The simplest forms connect directly with the angiocarpous Protobasidiomycetes (Pilacreæ). Accessory fruits (oidia) are known so far only for the Nidulariaceæ. The basidiospores of most Gasteromycetes do not germinate immediately, and consequently there is a difficulty in the way of studying this group in artificial cultures. For this reason, we know them only in the mature state and in stages leading directly up to this. Pro-

ceeding from simple to complex, the Gasteromycetes are subdivided into (1) Tylostomeæ, (2) Sclerodermiæ, (3) Lycoperdiaceæ, (4) Hymenogastreæ, (5) Nidulariaceæ, (6) Sphæroboleæ.

The Phalloideæ constitute a highly specialized group. In all of them a hymenophorous-chambered tissue, the gleba, develops within a closed envelope, the volva, which is ruptured at maturity by the upward pressure of a rapidly elongating special sporophore, the receptacle. This bears on its surface the one-celled basidia, which in turn bear the spores at their apex on very short sterigmata. Most species are tropical and not well known. The group is divided into (1) Clathraceæ and (2) Phalloideæ.

The book is dedicated to Dr. Brefeld, and ends, as it begins, with a general discussion of the relationships of fungi and a scheme of classification, which is here reproduced.

VON TAVEL'S OUTLINE OF A NATURAL SYSTEM OF THE FUNGI.

I.—Alga-like fungi.

Phycomycetes, with a one-celled thallus and sexual organs.

Class I.—Oomycetes. Sexual fructification in oospores; nonsexual in sporangia and conidia.	1. Monoblepharideæ.		Antheridia and oogonia in the form of sporangia; nonsexual sporangia.
	2.	Peronosporeæ. Ancylisteæ. Saprolegniaceæ. ?Chytridiaceæ.	Antheridia reduced; oogonia as sporangia; nonsexual sporangia or conidia.
	3. Entomophthoreæ.		Both antheridia and oogonia reduced; nonsexual conidia.

Class II.—Zygomycetes. Sexual fructification in zygospores; nonsexual in sporangia and conidia.	1. Exosporangia.	1.	Mucorineæ. Thamnidiæ.	Sporangia only.
		2.	Choanephoreæ.	Sporangia and conidia.*
		3.	Chætocladiaceæ. Piptocephalideæ.	Conidia only.**
	2. Carposporangia.***	4.	Rhizopeæ. Mortierellaceæ.	

II.—Higher fungi.

With septate thallus and without sexual organs.

MESOMYCETES.

(Intermediate forms connecting with the lower fungi through the Zygomycetes. Group relationships are indicated by asterisks, etc., corresponding to the termini of lines used by von Tavel.)

Class III.—Hemiasci. Fructification by sporangia and conidia; sporangia asci-like.	I. Exo-hemiasci.*†	1. Ascoideae. Protomycetes.
	II. Carpohemiasci.*** ††	2. Theleboleæ.
Class IV.—Hemibasidia. Fructification by conidia: no sporangia; conidiophores basidia-like.**	1. Ustilagineæ.†††	Conidiophores Protobasidia like.
	2. Tilletiæ.††††	Conidiophores Autobasidia-like.

Class V.—Ascomycetes. Fructification by sporangia and conidia; sporangia determinate, i. e., asci.

- I. Exoasci. † Asci free.
  - 1. Endomycetes.
    - Taphrineæ.
- II. Carpoasci. †† Asci in fruit bodies.
  - 2. Gymnoasci.
    - Perisporiaceæ. Angiocarpous.
    - Pyrenomycetes.
  - 3. Hysteriaceæ.
    - Discomycetes. Hemiangiocarpous.
    - Helvellaceæ.

Class VI.—Basidiomycetes. Fructification by conidia; no sporangia; conidiophores determinate, i. e., basidia.

- I. Protobasidiomycetes. ††† Basidia septate.
  - 1. Uredineæ.
    - Auriculariæ. Gymnocarpous.
  - 2. Pilacreæ.§ Angiocarpous (in both groups the basidia are divided crosswise).
  - 3. Tremellineæ.§ § Basidia divided lengthwise, gymnocarpous.
- II. Autobasidiomycetes. †††† Basidia not septate.
  - 4. Dacryomycetes. Gymnocarpous.§ §
  - 5. Gasteromycetes. Phalloideæ. Angiocarpous.§
  - 6. Hymenomycetes. Gymnocarpous and hemi-angiocarpous.

The book certainly deserves a wide reading, and students who are not thoroughly familiar with German will be glad to know that an authorized translation into English is now in preparation and may be expected during the year.—ERWIN F. SMITH.

WARD, H. MARSHALL. *The Diseases of Conifers.* <Jour. Royal Hort. Soc., vol. XIV, Oct., 1892, London, pp. 124–150 (in report of the conifer conference held at Chiswick Gardens, October 7 and 8, 1891).

This pleasant, popular paper discusses two classes of diseases, those due to fungi and those due to disturbing actions of the inorganic environment. The pines, firs, larches, junipers, and other conifers are taken up seriatim. Most of the facts presented have already been recorded, but for the general reader the paper has the great advantage of bringing together the scattered literature and presenting the main facts in a salient, suggestive way.

The premature shedding of pine needles is ascribed to several distinct causes: (1) Sharp frosts or nights so cold that the still tender foliage is chilled beyond recovery; (2) active transpiration when drought has removed the moisture from the soil, or in warm, sunny weather when the ground is frozen hard; (3) the action of various fungi, e. g., *Hysterium pinastri*, which is said to be one of the most prevalent and difficult to deal with.

Some general remarks on nonparasitic diseases of pines are worth quoting in full on account of their suggestiveness, but we must be content with the following:

> Speaking generally, the pines require light, open, and well-drained soils, as deep as possible, and many aspects of disease are due to the nonfulfillment of these conditions.
>
> Unquestionably one of the worst of these dangers results from clogging of the soil at the roots, whether due to wet clay, stagnant water, the covering up or hardening of the surface, e. g., by means of pavements, etc., or other processes.